UNITED STATES DEPARTMENT OF AGRICULTURE
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COTTON RESEARCH AND RELATED WORK OF THE AGRICULTURAL RESEARCH ADMINISTRATION

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The cotton research of the Agricultural Research Administration, together with its related activities in the control of insect pests, is designed to benefit both producers and consumers of cotton and cotton products by (1) increasing the efficiency of production and improving the quality of the cotton produced, and (2) finding new uses for cotton and improving the quality of the products already in use. The work includes both fundamental biological, chemical, and physical research and practical studies covering operations from the field to the factory and the home. Four of the bureaus in the Agricultural Research Administration are actively engaged in this work: Plant Industry, Soils, and Agricultural Engineering; Entomology and Plant Quarantine; Agricultural and Industrial Chemistry (mainly at the Southern Regional Research Laboratory, New Orleans, La.); and Human Nutrition and Home Economics. In addition, the Research Administration Office of Experiment Stations handles the funds appropriated by the Federal Government for research by the States, including cotton research. A considerable amount of the State research is in cooperation with ARA bureaus.

STUDIES OF FIBER QUALITY AND PROPERTIES

Fundamental studies of the formation and growth of the fiber and of the structure of the fiber wall have supplied an understanding of the variations that exist in length, strength, and quality. It was found by microscopic and X-ray studies that the structure of the fiber from different varieties is different and that fiber structure is related to strength of fiber and strength of yarn. Methods have been devised for measuring individual fiber properties. Genetic research has revealed how strength, length, structure, and fineness of fiber are inherited, and manufacturing tests have indicated how these properties and combinations of them contribute to spinning performance and use value. All of this information has been utilized to evaluate the different varieties and determine their quality and mill value.

Chemical and X-ray studies of the composition and structure of the fiber are pointing to methods of treatment that improve the quality of cotton products and lead to new uses.

COTTON PRODUCTION

One-Variety Production

Since 1934 the development of one-variety communities throughout large parts of the Cotton Belt has been one of the outstanding achievements in our southern agriculture. The program, under consideration for many years, was begun in 1931, when there was general agreement that the one-variety plan offered the best prospect of continued successful production of cotton in this country. The practicability of production standardized on one variety had already been demonstrated in the irrigated valleys of our Southwestern States.

In 1943 there were 2,544 one-variety communities in various stages of development in 569 of the total of 736 cotton-producing counties in the United States with a membership of 305,801 participating farmers who planted 8,869,298 acres of cotton. This was more than one-third of the total acreage planted to cotton in the United States in that year. The extra cash return received by the growers in the one-variety communities in 1943 from larger yields and premiums for improved quality of staple is estimated at nearly $7.50 an acre over and above what they would have received if they had continued to plant the inferior varieties formerly grown. This represents a total additional income for the one-variety farmers of more than $66,000,000 in a single year.

The large supplies of pure seed of improved varieties of cotton with better staple that are always available in the one-variety communities made it possible to meet in a single season the exacting requirements of strength and durability for fabrics that went into the thousands of articles needed in the war.

Experience has shown that where production is on a single-variety basis, improvements in culture, harvesting, ginning, and marketing are more easily and effectively applied and the textile industry is assured of regular supplies in large volume of more uniform cotton of the same character of staple.

Cotton manufacturers through the South have recognized the superior quality of the one-variety cotton and many mills are now regular customers of communities where large blocks of the one-variety cotton of specific varieties are available.

The one-variety communities using recently developed varieties of superior quality are probably producing the best cotton in the world. Standardizing our entire production on a few of our best varieties is a logical future step.

Breeding Improved Varieties

Genetics and breeding research has developed techniques which make possible more rapid development of superior strains and varieties, and the new measures of quality referred to earlier are being applied in this work. The older varieties that were widely grown in different sections, especially strains of Cleveland and Mebane, produced relatively weak fiber, and this contributed in a large measure to the poor reputation of American cotton with European and some of the domestic mills. The staple length of our cotton has been increased and the widespread planting of such varieties and strains as Stoneville 2B, Deltapine 14, Acala 1517, Coker 100, and Wilds has given us cotton of much greater strength than was the case a few years ago. With one-variety communities, the varieties with desirable qualities can be brought into wide production very rapidly.

Soil and Fertilizer Investigations

Researches with legumes, fertilizers, cropping, soil management, and cultural practices have provided a basis for maintaining and increasing yields and have increased production efficiency. Turning under legume crops has increased yields from 100 to 700 pounds of seed cotton per acre, the average increase being about 300 pounds While a complete fertilizer is usually required for cotton, nitrogen is the element needed in largest amount in most areas, though where cotton follows peanuts or soybeans potash is apt to be the limiting factor. Different varieties respond differently to some of the fertilizer elements. Light foliage varieties, for instance, require more potash than do those with heavy foliage. Improved fertilizer practices on some soils have increased oil content of seed, retarded certain diseases, hastened fruiting and maturity, and improved the quality of lint. Since high acre yields are essential for economical production, research along these lines continues to yield profitable returns.

Fortunately, soil maps, based on a comprehensive system of soil classification, have been made for considerably more than one-half of the area where our cotton is produced; but they are lacking in a good many important counties, and a few others, where the mapping was done many years ago, need to be remapped,

During the past 10 years increasing emphasis has been given the rating of the soil types according to the yields of adapted crops under various systems of management. This research has shown that the soils of southern United States vary widely in their adaptability to cotton. Many of those on which cotton cannot be grown efficiently are, however, well adapted to other crops. Further, the most efficient system of management for cotton production varies widely according to soil type. These greatly variable soil types are so intricately intermingled that each farm has its individual potentialities. One field may be well adapted to cotton and an adjacent one not, even though it is well adapted to some other valuable crop. It has been demonstrated that through consideration of such facts as the fundamental productivity of the soils and their responses to fertiliz lime, and other management practices, the efficiency of crop production on the individual farm can be greatly increased.

The completion of the soil maps and the further development of accurate productivity ratings for all soil types for adapted crops under various systems of management should contribute significantly to the efficiency of cotton production.

Control of Diseases

Cotton diseases greatly increase the hazards of production. In some cases they destroy the entire crop and in others reduce the yield. Research has aided in reducing the losses from seedling diseases, boll rots, rusts, and other diseases that occur over the entire Cotton Belt. Some farms where root rot and wilt and similar diseases are severe have been saved from abandonment. The control measures developed involve seed treatment, crop rotation, soil management, fertilizer practices, and the breeding of resistant varieties.

Prevention of Losses from Insects

Insect losses are an important item in the cost of production. According to the estimates of the Bureau of Agricultural Economics, the reduction from full yield due to insects averaged 13.1 percent annually from 1923 to 1943. The loss was over $700,000,000 in 1923 (the year the boll weevil became well established along the Atlantic Seaboard) and averaged about $230,000,000 annually for this 21-year period. The average annual cost of insect damage per pound of lint harvested during this period (1923-43) is estimated at 3.8 cents. It is thus evident that efficiency in production can be materially increased by reduction of insect losses.

Keeping out foreign pests.--In the other cotton-growing countries of the world there are numerous pests of cotton that do not occur in this country and that would cause serious losses if they should be accidentally introduced and established in the United States. The quarantines against foreign cotton and cotton products have been successful in preventing the introduction of most of these pests. The entry of the boll weevil and pink bollworm occurred by flight from the adjacent areas of Mexico. Inspectors at ports of entry enforce quarantine regulations designed to prevent the introduction of pests without unduly interfering with the entry of foreign cotton.

Control and eradication measures.--The pink bollworm is today the most serious insect menace that has ever confronted the cotton industry in this country. In most of the other cotton-producing countries of the world the damage it causes is comparable to that of the boll weevil in the United States. Its general establishment in this country would threaten cotton production over large areas.

The pink bollworm was found in the United States more than 25 years ago, but persistent efforts have so far prevented its spread over the Cotton Belt. It is established in Texas in areas adjacent to Mexico, and light infestations occur in a number of other counties in Texas, New Mexico, and Arizona. Last year it was found in two parishes in western Louisiana, in one of which a non-cotton zone is now in effect. A number of additional counties in Texas were found infested this year.

Suppressive measures used to reduce the pink bollworm population and the danger of spread include the regulation of date of planting, cleaning of fields, sterilization of seed, fumigation or other treatment of cotton lint, and quarantines against movement of infested products to other areas. This effort has become increasingly difficult and the work can be accomplished only if the whole cotton industry recognizes the importance of the pink bollworm and supports the control program.

Because of reinfestation by flight of moths, permanent eradication of the pink bollworm from the United States is dependent on a similar effort in Mexico at the same time. Mexico is cooperating with our Government in suppressive measures, but although conferences between United States and Mexican officials have been held to consider the possibility of eradication in both countries, such a program has not been undertaken. The only known method of eradication is to establish a non-cotton zone, which requires the elimination of all cotton, okra, and possibly other host plants over large areas, and legislation and appropriations by participating States. The difficulties of such a procedure might be overcome or reduced by using the non-cotton zone as part of a cotton acreage reduction program when circumstances warrant.

In limited areas, the white fringed beetle is another foreign pest of cotton against which suppressive and preventive measures are being used.

<u>Development and improvement of methods of control</u>.--That progress has been made in insect control is evident to all who recall the bankruptcy, demoralization, and panic in the cotton industry caused by the spread of the boll weevil across the Cotton Belt.

The development of calcium arsenate as a boll weevil insecticide saves cotton growers each year many times the $5,000,000 or less spent by the Government on cotton insect research since the work was first undertaken. The Extension Service of Alabama (Annual Report of State and County Extension Agents, 1943) estimates that the 4½ million pounds of calcium arsenate used in Alabama in 1943 saved cotton valued at over $6,250,000 from the boll weevil, or nearly $1.50 for each pound of the insecticide used. Since 1918, when calcium arsenate was first recommended for boll weevil control, its use has increased until approximately 65 million pounds were manufactured in 1943, most of which was used on cotton.

Control of the cotton flea hopper by methods developed by research often increases the yield by 25 to 100 percent; and control of Lygus and other bugs in the irrigated sections of the Southwest increases the yields and improves quality of cotton enough to add $10 to $15 an acre to the profits of growers.

Despite the progress that has been made, much remains to be done in developing control measures for insects for which no adequate control is known, in reducing the costs and improving the efficiency of methods now in use, and in securing more general use of these measures by growers. The pink bollworm presents one of the most pressing problems. None of the insecticides in general use are effective with this insect.

When calcium arsenate is used to control the boll weevil, damage caused by the cotton aphid is increased; and light sandy soils are also injured by this insecticide. Means of overcoming these difficulties would greatly increase the profits of growers and stimulate the wider use of calcium arsenate for weevil control. Improved methods of application are also needed. There is need of a more effective insecticide for the boll worm. Control methods for the cotton flea hopper that have given good results in the Gulf Coast area of Texas should be tested in the drier areas of that State and of Oklahoma. Control developed for the sucking insects that attack irrigated cotton in the Southwest is profitable, but it is known that much of the damage by these insects is not prevented; a more effective insecticide is needed especially for the stinkbugs that reduce the quality of the lint.

The new insecticide, DDT, has given encouraging results against the bollworm, some of the sucking insects, and the pink bollworm, but its effects on the soil and on plants have not been established. It shows little promise for the control of the boll weevil and the cotton leafworm, the two cotton insects for which the greatest quantities of insecticides are used, and it is of no value against the cotton aphid. However, the discovery of DDT has stimulated research on new synthetic insecticides. The thousands of organic materials that should be tested against cotton insects afford unlimited possibilities in the field of new insecticides and repellents. Other opportunities for more economical insect control are by the introduction of natural enemies and the breeding of varieties resistant to insect attack.

Surveys conducted to obtain information on the abundance of insects and the need for insecticides have been of value during the war. This year, 25,000 fields were examined for boll weevils, 5,000 for flea hoppers, and several thousand for leafworms and other insects, and the information obtained aided in the orderly distribution of insecticides and in advising growers when and where control was needed.

A difficult problem in insect control is to get timely use by growers of the methods that have proved effective. Adoption of control measures has been delayed because there are so many small growers and because the custom of planting more acres to take care of insect losses is so well established. Insect control is as essential in the economical production of cotton as is cultivation or the use of fertilizers, and it should be a regular farm practice.

Some of the changes and adjustments in cotton production that may be made after the war will undoubtedly intensify insect damage unless proper precautions are taken. On the other hand, the many new developments that have resulted from the war--new chemicals, new processes of manufacturing, new devices for applying insecticides, and new materials for improving dusting and spraying machinery--will provide better tools for insect control.

COTTON GINNING

Unlike many farm crops, cotton must be partially processed before it is sold so that any improvements in the ginning process result in an immediate and direct benefit to the producer. They are important also to industry since poor ginning makes a poor product, and natural quality destroyed in the gin cannot be restored.

The Cotton Ginning Laboratory, established at Stoneville in 1930, has developed improved methods which have been largely adopted by ginners in both the rain-grown and arid sections of the Cotton Belt and have resulted in better and cheaper ginning, better prices for growers, and a more valuable product for industry. The work at this laboratory is done in cooperation with the Office of Distribution of the War Food Administration and with the Mississippi Agricultural Experiment Station.

Miscellaneous Ginning Improvements

Over 20 Public Service patents have been taken out by the laboratory's technicians covering a series of improvements in gin machinery which are now coming into general use in all modern gins. Among the outstanding developments has been the cotton drier, by means of which cotton with high moisture content can be adequately ginned, thus enabling the gins to operate more continuously. The laboratory has also demonstrated the mechanical and economic feasibility of baling cotton at gins at a standard density of 22 pounds rather than at a low density of 11 pounds per cubic foot. Thus a 500-pound bale is reduced in size from about 54x27x45 inches to about 56x28x22, or about 50 percent. This large reduction makes for easier handling, reduces space requirements in storage houses and freight cars, and makes possible more direct and rapid transfer from the gin to the textile mill. High-density bales also go at a lower freight rate than those of low density.

The laboratory has worked out many other improvements--for example, better bale coverings; permanent identification tags which obviate the necessity for continued sampling; a modification of the gin baling mechanism which almost entirely prevents air cuts and also gives a bale with uniform density, thus doing away with rolling and big-end bales, which have been the cause of much difficulty and added expense in compressing; and various minor improvements in ginning machines and their operation, such as higher operating speeds, the use of the loose seed roll, better shapes of saw-teeth, improved pneumatic conveyors, and power-saving devices.

The importance of pure seed is such that the engineers have listed and recommended methods and equipment by which farmers can be assured of getting their own seed, even when the ginner handles several varieties of cotton.

<u>Cleaner Lint Cotton</u>

The Stoneville Laboratory is putting special emphasis on the development of better cleaning of cotton at the gin. Under present practices, all of the cleaning operations are done before the seed cotton reaches the gin saws. However, after ginning there is always a considerable amount of fine dirt and trash in the lint, sometimes as much as 5 or even 10 percent of the weight of the bale. In baling and compressing, this pepper trash is embedded in the lint and its removal at the mill is an expensive operation. The logical place to remove this dirt is at the gin, between the saws and the bale press, and investigations to develop equipment for this purpose are now under way. If successful, this improvement will increase the price received by the farmer, since the amount of pepper trash has considerable effect upon cotton grade. It will also reduce freight costs and speed up operations at the mill.

Unfortunately, much of the cleaning machinery necessary for good ginning is somewhat elaborate and expensive. It is beyond the reach of one- or two-stand gins with small annual output. Existing equipment should be modified or adapted to enable the small gins to do a better job without too much capital expenditure.

With the advent of the mechanical picker, the cleaning of cotton and the extraction of foreign matter will be problems of major importance. Mechanical cotton pickers have been developed and are being used to some extent in the picking of cotton, but no machine has yet been designed which does not gather a good deal of trash, leaves, and other foreign material. With present equipment the machine-picked cotton has a minimum of 5 pounds per bale of trash in excess of that contained in hand-picked cotton. Consequently a good part of the savings made in the picking are offset by reduced prices received for the cotton. The engineers are testing the use of chemicals for defoliating the cotton plants prior to mechanical harvesting in order to reduce the amount of trash picked with the cotton.

COTTON UTILIZATION

Cotton Fiber

The cotton utilization studies of the Southern Regional Research Laboratory include those on (1) the chemical and physical properties of cotton fiber, (2) the alteration of fiber properties and the effect of changes on finished cotton products, and (3) the modification of the properties of manufactured cotton products by various constructions and by finishing treatments. These studies are related to the production of cotton products with certain desirable characteristics. For example, the characteristics of manufactured products depend fundamentally on the fine structure of cellulose in the cotton fibers; and to produce stronger or more lasting products, it is necessary to understand the effects of light, heat, and chemical agents on the degradation of the cotton fiber and on the process of commercial cotton bleaching. To develop an improved cotton product such as a better tire cord it is necessary to study the effect of high temperature on cotton product, the mercerization characteristics of cotton of different varieties, and the effect of chemical modification or impregnation on the properties of cotton products.

As a result of such investigations a new, unlined fire hose has been produced, and an all-cotton elastic bandage is in small plant production, using several thousand yards of cotton cloth. The stabilization of nitrocellulose has been improved and test runs of a new stabilizing process have been demonstrated on full scale 2½-ton lots. A new and improved machine for slashing cotton textile warps is being fabricated, and also a machine for opening, cleaning, and blending cotton for textile processes.

Among the investigations on the modification of properties of manufactured cotton products by various constructions and by physical and chemical treatments are studies on the preservation of cotton fabrics against decomposition caused by weather, sea water, and micro-organisms; methods of improving flameproof, fireproof, and waterproof properties of cotton fabrics; and special finishes to improve the strength and durability of cotton products. The effect of swelling and stretching treatments on the properties of tire cords are being evaluated, and the elasti properties of cotton tire cord are being studied. The development of heat resistant tire cord from mercerized yarns is under way.

Through these investigations, methods for determining the resistance of treated cotton fabrics to weather and micro-organisms have been devised. Experimentally, a fireproofing method has been developed for lightweight cotton fabrics which will withstand a dozen laundry trials.

Other investigations include the improvement of the adhesion of cotton tire cord to rubber and synthetic rubber, and the relationship of cotton tire properties and the construction of the cord to its "flex life" and tensile strength. An improved tensioning apparatus for the manufacture of cotton cord has been developed, and electronic, high frequency heating has been used for improved and rapid drying of cotton yarns and fabrics.

The effects of the treatments mentioned on the properties of tire cord and other cotton products are now being evaluated as part of an appraisal of cotton compared with other products for tire cord. Field tire tests, although as yet few in number, as well as laboratory tests have shown that the special cotton tire cords developed from these investigations consistently and materially outperform commercial cotton tire cords.

Cotton Seed

An inexpensive ammonia preservation process for the control of temperature and the free-fatty acid content of moist cotton seed has been so successful in ton-lot experimental runs that some plants are trying it on full commercial scale this season. Success of the process would mean the saving of large volumes of useful cotton seed oil now lost.

Cotton seed oil.--Investigations are being made in the modification of cotton seed oil to improve its usefulness in industry and provide new outlets. These include the physical behavior and characteristics of the oil under processing conditions, the composition of the oil and its by-products in relation to industrial utilization, and improvement of the flavor, odor, and keeping qualities of cotton seed oil and its derived products.

The work has demonstrated commercially that properly modified cotton seed oil can replace palm oil in tin and terne plate industries. Although the cost of the modified oil would be twice that of palm oil, its expected life in processing should be three times as long. The investigations have also shown that by a combination of controlled hydrogenation and low temperature solvent fractionation a hardened fat can be produced from cotton seed oil which has the consistency and other properties of imported cocoa butter, used extensively in foods, confectionery, and pharmaceutical products. With the same processing technique, a substitute for olive oil as a worsted lubricant has been made from cotton seed oil.

Substantial contributions have been made to methods and processes for improving the keeping qualities of oils, fats, and shortening, particularly for Lend Lease and Army shipments to the tropics. The investigations on the stability of cotton seed oil and the use of anti-oxidants have contributed to these advances.

Cotton seed meal and protein.-- As a result of the investigations on cotton seed meal and protein, adhesives have been developed from the meal which are adaptable in the field of tacky and rewettable glues for which there are enormous demands. Information developed from fundamental studies on the constituents of cotton seed and cotton seed meal, particularly on its enzyme system, are expected to contribute materially in the processing of the meal for the manufacture of new and improved industrial products.

Cotton Fabrics in the Home

Investigations in the home economics laboratories are concerned with designs and finishes for knitwear, especially women's cotton hose, for superior appearance, fit, and quality. Home economists have also cooperated with other agencies in formulating specifications for certain cotton fabrics. Other work with cotton products includes the making of designs for aprons, dresses, and children's garments that combine attractiveness with high functional utility.